Humanities and Social Sciences
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Report based on the Symposium on Creativity and Innovation in the Arts and Sciences
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Preface

For several years now, it has been apparent to many observers that if the economic, social, and even physical well-being of Canadians is to be enhanced in the 21st century, Canada's governments, educational institutions, and granting agencies must work in concert to foster and support the creativity and innovation upon which success increasingly depends in the brave new world of DVDs, Auto-CAD, bioengineering, and a host of other recent and emergent technologies and disciplines. Such, in any event, was the perception that prompted me in November 1998 to write to the Chair of the Canada Council, the President of the Humanities and Social Sciences Federation, the presidents of the federal granting agencies, and the Deputy Prime Minister, the Honourable Herb Gray, to urge the creation of "a Task Force on Creativity, Inventiveness, and Innovation whose mandate would be to explore and identify ways in which new and original ideas can be encouraged and developed across the full spectrum of the arts, sciences, medicine, social sciences, business, industry, and technology in Canada for the use and benefit of all Canadians." The Symposium on Creativity and Innovation in the Arts and Sciences of which the present Report is a product was the result of that suggestion, and a testament to the generous support of the HSSFC, the Social Sciences and Humanities Research Council, the National Research Council, and the University of Alberta. The Symposium's greatest debt, then, is to Louise Forsythe, Marc Renaud, Arthur Carty, Peter Hackett, Garth Williams, Paul Ledwell, and others at the HSSFC, SSHRCC, the NRC, and the University at Alberta whose generosity and enthusiasm brought it to fruition at the Congress of the Social Sciences and Humanities in Edmonton on May 25 and 26, 2000. That the Symposium was the success to which this Report testifies was due to the technicians who made many portions of it possible, to the participants who made every moment of it both instructive and delightful, and, last but by no means least, to its principal organizer and amanuensis, the indefatigable and imperturbable Marc Spooner.

Whatever else they may be, creativity and innovation are processes that bring useful and valuable ideas and things into existence. As this Report attests, the Symposium on Creativity and Innovation in the Arts and Sciences was part of such a process — an occurrence (and, occasionally, a happening) in a series of actions and events whose future outcomes, it is greatly to be hoped, will be of use and value to all Canadians. Of course, the Report, so ably assembled by Professor Spooner, is a further and crucial occurrence in that series — crucial because it is the major stage in generating radical thinking and radical action by those who can assist in decisive and constructive ways in fostering and supporting creativity and innovation in Canada. Thus a final debt of gratitude must go to the Honourable Herb Gray, who not only travelled to Edmonton to address the Symposium with his

characteristic wit and wisdom, but has also undertaken to ensure that the substance and recommendations of this Report will be given serious consideration by the Federal Government.

D.M.R. Bentley, FRSC
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Coordinator's Message

As coordinator of the Symposium on Creativity and Innovation in the Arts and Sciences, I am pleased to submit the following Report, which represents highlights and themes that emerged from the presentations and discussions that took place in the course of the two-day Symposium at the University of Alberta on May 25 and 26, 2000. The Report does not attempt to do justice to the wide array of topics centred on the creativity theme that emerged at the Symposium; rather, it aims to provide a brief and informative overview of several of the important issues that arose, particularly those that relate to the role of education, Granting Councils, and the Federal Government in fostering and supporting creativity and innovation. Numerous other promising directions of enquiry and many issues of greater specificity also emerged from the Symposium but are necessarily mentioned only in passing in this Report.

The recommendations flowing from the Symposium can be viewed as a consensus for increased participation at every level of education and government in the promotion of creativity and innovation as crucial sources of the future wealth and standard of living of all Canadians. If Canada is to continue to move forward, creativity and innovation must be recognized as key components of Canadian society in the 21st century.

The following Report is based on a collection of information sources that include personal and rapporteur notes, audio recordings of sessions, speakers' notes, as well as scholarly publications and Provincial and Federal Government reports.

Yours sincerely,

Marc Spooner
Coordinator, Symposium on Creativity
and Innovation in the Arts and Sciences
Edmonton, Alberta
May 25–26, 2000

Acknowledgements

Both personally and on behalf of the Humanities and Social Sciences Federation of Canada (HSSFC), the Social Sciences and Research Council of Canada (SSHRC), and the National Research Council of Canada (NRC), I would like to thank all the participants in the Symposium on Creativity and Innovation in the Arts and Sciences held during the 2000 Congress of the Social Sciences and Humanities at the University of Alberta in Edmonton on May 25 and 26, 2000.

The Symposium exceeded its goal of bringing together in constructive colloquy researchers from across Canada and beyond in the natural, applied, and social sciences as well as the arts and humanities to discuss the topic of creativity and innovation. The inspiring spirit of collaboration among the disciplines could be readily and continuously felt as presenters and audiences alike explored suggestions and solutions for promoting creativity and innovation in Canadian society.

That the Symposium was a success on so many levels was due in great measure to its participants, all of whom deserve thanks for their time, effort, insights, and wisdom. Once again, a heartfelt thank you for your interest and effort in this regard. A special note of thanks goes out to Professor David Bentley, Garth Williams, Paul Ledwell, and the University of Alberta for helping to bring this idea to fruition.

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Executive Summary

"No country can afford to neglect its creative minds."

Dr. Frederick Banting
(as cited in Jackson, 1976, p. 199)

> *Canadians realize that innovation is vital. It is the foundation of our economic and social prosperity ... To be successful, we need a steady stream of new ideas...*
>
> *Sustaining Canada as an Innovative Society: An Action Agenda*, 1997, p. 5

It is widely agreed that if Canada is to continue to develop and prosper in the 21st century, creativity and innovation are of key importance. The health and wealth of organizations, cultures, and nations are rooted in human capital and the generation of productive ideas. In order to maintain and improve the Canadian quality of life both individually and collectively, the generation and promotion of such ideas by Canadians must be encouraged at every level: individually, scholastically, organizationally, and culturally.

Focus

This Report is focussed on themes and recommendations that emerged during the two-day Symposium on Creativity and Innovation in the Arts and Sciences Symposium held in conjunction with the 2000 Congress of the Social Sciences and Humanities, University of Alberta, Edmonton, May 25, 26, 2000.

Defining Creativity:

> *Creativity is imaginative, motivated, transformative, and productive thinking and activity within a particular context or framework of knowledge, inquiry, and skills — a process that generates outcomes which are original, significant, effective, and of value or use (or both) to the community.*
>
> Definition of creativity generated by the question "What is creativity?" posed during the opening session of the Symposium

Main Directions

> *The most wealthy nations and regions of the world are the most innovative;*
>
> *Most new jobs depend on innovation;*
>
> *Innovation is a renewable source of wealth, and the status quo is not a viable option.*
>
> *creating an innovation culture: Key Challenges and Opportunities as Ontario Moves Ahead in the New Millennium*, 1998, p. 3

What follows is a blueprint for the direction in which Canada needs to advance if it is to continue to compete successfully in a knowledge-based economy. The aim of this Report is to increase the economic prosperity and quality of life of all Canadians. More specifically and most important, it is a prospectus for fostering creativity and innovation as vital components of a vibrant, healthy, and prosperous people and nation. Canada must continue to enhance its position as a nation where creativity and self-actualization, originality, and innovation are openly encouraged, fostered, and rewarded.

Emergent Themes

1.0 Creativity: The Process

Creativity is a process that can be taught and learned by all. Creativity should be viewed as a process, a way of thinking, not exclusively an act, an event or a product. It is a learned skill, not an innate trait or gift that some people possess and that others do not. Creativity requires tools and thinking patterns that are convergent as well as divergent, logical as well as intuitive, and evaluative as well as generative.

Creativity is frequently an "effective surprise" but it is also the painstaking result of trial and error.

When we speak of creativity and innovation, we are not simply discussing the introduction of new goods or services to the market. Moreover, focussed, targeted problem-solving is typically not activity of the most creative and innovative kind.

2.0 The Value of Art–Science Interaction and the Benefits of Multi-disciplinary Study and Teamwork

The best artists and scientists combine elements, skills, and tools from a variety of sources. In order to foster a culture of creativity, Canadian governments and schools must actively promote a culturally literate populace, capable of integrating and synthesising various forms of knowledge-creation.

"History shows that the sciences and technology have never flourished in the absence of a similar flourishing of the arts" (Root-Bernstein, 1997, p. 15). Renaissance Italy is a case in point, as are nineteenth-century Britain and France.

3.0 Recommendations for Governments, Schools, and Granting Councils

3.1 Encourage Multi-disciplinarity

a) Schools should continue to encourage an integrated curriculum with assignments and classroom activities that are problem — rather than discipline-based.

b) Universities should promote cross-disciplinary study, for example, allowing and encouraging students to combine seemingly unrelated fields such as music and engineering or computer science, history, and education.

c) The Federal Government should make additional funds available to the Granting Councils that are specifically earmarked for joint council sponsorship of truly cross-disciplinary initiatives — not just teams from closely allied disciplines.

3.2 Risk, Play, and Great Expectations

d) Granting Councils should allow for numerous small research grants to be allocated to projects that are seen as high-risk, highly likely to fail, but nonetheless low-risk in terms of monetary investment and potentially high-gain in terms of creativity and innovation.

3.3 Time to Explore and a Tolerance for Ambiguity

e) Granting Councils should also be willing to tolerate basic research that flows in unspecified directions, is flexible in nature, and that follows ad hoc and intuitive ventures into unexpected areas.

3.4 Individual and Organizational Re-invention

f) In order to push the boundaries of excellence, organizations should remain fluid enough to allow for the rapid formation and dissolution of teams that find themselves excited by particular problems.

g) Universities should be flexible, perhaps allowing a certain percentage (5%) of any curriculum to be comprised of elective courses that bypass standard assessment procedures typically involved when attempting to introduce new courses. Programs should be reevaluated and possibly redesigned every five years.

3.5 Creating a Culture of Creativity and Innovation

h) Education conceived as a critical and dialectical process (Popper, 1994) between the individuality

of the child and a cumulative and diversified knowledge is the best means to foster creativity in a society.

i) If the Federal Government truly wants to create a culture of creativity and innovation, then it must also encourage and make additional funds available for exchanges between researchers from diverse cultures.

j) Granting Councils should reward researchers who have been successfully creative and innovative in the past, even if they are now looking to challenge their creative minds by attempting to work in new fields.

k) Governments should be sponsoring colloquia, debates, and public lectures on the topic of creativity and innovation in the Arts and Sciences.

l) The general public must be made aware of the increasingly crucial importance that creativity and innovation are playing in the knowledge-based economies of the 21st century.

m) A greater awareness and respect for the cross-pollinary effects and seminal importance of Science–Art interactions must also be generated, for, as observed earlier, science and technology have never flourished in the absence of a similar flourishing of the arts.

n) Professor Bentley's call for the formulation of a Task Force on Creativity, Inventiveness, Innovation, and Culture, falling under the combined aegis of the Granting Councils (Canada Council, CIHR, NSERC, and SSHRC), the Humanities and Social Sciences Federation of Canada (HSSFC), the National Research Council (NRC), as well as other interested agencies and organizations, should be acted upon.

Part A: Creativity: The Process

Creativity research is typically undertaken from the perspective of either the person (traits), the product, the process, or the press (environment). However, in the past an overemphasis has been placed on the person (traits) and the products resulting from creative endeavours. It is now largely agreed that it is far more useful to focus on creativity as a process and to illuminate environments that foster this process. But first, given the nebulous nature of creativity as a concept, assumptions and positions must be clarified, folklore and myth debunked.

Creativity can be fostered and taught. Creativity, as a process, is a way of thinking. It is not exclusively an act, an event, or a product. It is not necessarily an innate trait or gift that some people possess and that others do not (though a disposition towards creativity may be partly predetermined), but rather it is a learned skill. It should be noted that creativity is not a characteristic of persons irrespective of specific achievements. That a person may exhibit certain personality traits or cognitive attributes — for example, fluency, flexibility, spontaneity, risk-taking, and divergent thinking — may be helpful but they are not on their own enough to constitute a creative person.

Creativity requires tools and thinking patterns that are convergent as well as divergent, logical as well as intuitive, and evaluative as well as generative. Contrary to popular belief, creativity is not the result of a radical break with tradition; rather, it seems that creative offerings lie on a continuum — in one direction, an originality that occurs within the constraints of a given tradition, and in the other, an originality that involves an alteration of some aspects of the constraints themselves. Paradigms shift when a critical number of a tradition's constraints are altered (Kuhn, 1996). In other words, known concepts are either extended into new areas of application, or in the highest-order creativity, altered is the universe of meaning itself (Ghiselin, 1963).

1.1 Recognizing the Problem

Creativity is a process that involves the invention or recognition of a problem, the solutions to which are likely to be surprises to both the creator and to his or her peers. Creativity is, as Jerome Bruner has observed, an "effective surprise." It is the painstaking and wondrous result of trial *and* error, and a comfort or tolerance for ambiguity.

As the Nobel prize-winning chemist Sir Harry Kroto states, "nine out of ten of my experiments fail, and that is considered a pretty good record amongst scientists"

All Our Futures: Creativity, Culture and Education, 1999. p. 34

Creativity is the purview of perseverance with "chance favouring only the prepared mind," a slogan Louis Pasteur was fond of stating.

As cited in Hayes, 1989. p. 136

1.2 Innovation: More Than New Goods and Services

Let us be clear that when we speak of creativity and innovation, we are not simply discussing the introduction of new goods or services to the market. Rather, as stated in *Closing the Gap: Investing in Knowledge for a Better Canada* (1998), "to promote economic growth and the well-being of Canadians, we must look beyond the customary approach to innovation that focusses solely on technology-based innovation" (p. 8).

Technology-based innovation may be one component of innovation, and rightfully an important one; however, creativity that is far-reaching, that leads to transformative innovations, is creativity that is curiosity-driven and frequently serendipitous. Focussing on targeted problem-solving is typically not research activity of the most creative kind.

Studies of innovation in the biomedical sciences show that over fifty percent of biomedical breakthroughs occur from projects funded for other purposes... By the time something is fundable, it is long past being creative. Funded projects are those that fill in acknowledged gaps using acceptable methods. Surprises are not expected nor desired.

Root-Bernstein, 2000. p. 9

It is crucial that governments, schools, and Granting Councils continue to realize that, although projects may be discipline-based, problems and their solutions are not.

But how can organizations, schools, and Granting Councils develop environments that encourage the creative process to flourish?

Developing and enhancing the creative process, and fostering environments conducive to creative enquiry and innovation will be the focus of **Part B** of this Report.

Part B: Enhancing Creativity

2.0 The Value of Art–Science Interaction and the Benefits of Multi-disciplinary Study and Teamwork

Creative thinking is facilitated in individuals who possess complete, well-rounded, and complementary forms of literacy and/or numeracy. The pathway to understanding is discovered using complex and inter-related human tools, intelligences, perceptions, and sensibilities. The best artists and scientists combine knowledge, skills, and tools from a variety of sources.

> *...many scientists employ the arts as scientific tools. Moreover, various artistic insights have actually preceded and made possible subsequent scientific discoveries. The arts thus can stimulate scientific progress, and we dismiss them at our peril.*
>
> *History shows that the sciences and technology have never flourished in the absence of similar flourishing of the arts. The reasons for this connectedness have become apparent in the past several decades... A consensus is emerging that scientists and engineers need skills associated with, and often learned from, the arts.*
>
> *Clearly, the arts are not the useless, frivolous, or purely subjective pastimes they are often portrayed as being. My thesis is therefore very simple: If we let the arts atrophy in this country through lack of public support, we also will lose an important part of the creative base from which the next generation of scientific and engineering breakthroughs will emerge.*
>
> Root-Bernstein, 1997, p. B6

In order to foster a culture of creativity and innovation, it is of foundational importance that all citizens are given a full opportunity to achieve a high level of literacy and numeracy. In the new knowledge-based economy, governments must encourage a culturally literate populace, capable of integrating, synthesising, and advancing various forms of knowledge creation.

> *What does fostering Canadian industry's economic competitiveness have to do with history, sociology, English literature, or any of the other many disciplines that comprise the social sciences and humanities? The reality is, a lot. As 30 CEOs of Canadian high-tech companies recently said in a public letter, they need more than merely technical training. They need people who are trained in the social sciences and humanities as well.... Not only must we make wise investments across the entire spectrum of disciplines and fields of knowledge in both the physical and social sciences but just as critical is the creation and maintenance of links between them. Over the past several years, there has been much study on the question of whether the humanities and social sciences have a place in the new economy — and the answer has been a resounding YES. The*

reasons are not hard to find. In a knowledge-based economy, the skills acquired in a social sciences or humanities education are relevant, readily adaptable, and indicate a searching intellect. Businesses competing in a global economy need ... people who are able to discern emerging patterns of behaviour. They need people who know how to find answers, or where to look for information that will help them draw their own conclusions. They need people capable of lifelong learning, and who address new challenges as opportunities to explore new ideas and develop new skills.

The Honourable Herb Gray, P.C., M.P.
Edmonton Symposium

Given the fragmentary nature of current knowledge, the sort of comprehensive knowledge idealized in the "Renaissance person" may no longer be an attainable reality; however, the Renaissance team is most certainly achievable. Research teams comprised of members from a variety of disciplines have a greater likelihood of developing innovative solutions to given problems.

How does encouraging multi-disciplinary study and teamwork work?

Keeping in mind that creativity is a process, it may be counterintuitive to conceptualize this process as identical among various domains and disciplines. Nevertheless, the variety of *tools* that facilitate creativity and innovation and that are employed by the world's most creative people may be taken collectively as a common set. For example, artists, scientists, researchers, educators, and inventors share in various combinations and degrees the same cognitive and intuitive tools at the core of creative understanding; however, the manner in which they utilize these tools and the creative products that result are manifest in substantially different ways, depending on their disciplines of choice. Within disciplines, specific styles of thinking tend to be emphasized at the expense of others. At the same time, each thinking style and/or tool is equally valuable for creative understanding, and together as a set operate synergistically.

2.1 The Creativity Toolbox

Metaphors, empathetic thinking, and imagining are often useful in pattern-breaking and seeing in new ways. Multi-disciplinary work facilitates the discovery of preconceptions and habits of thought, and this, in turn, leads to the extension, modification, and variation of thinking styles. Multi-disciplinary collaborations promote new ways of observing and create an awareness of old patterns as well as new ones. Multi-disciplinary teams and training facilitate seeing not only what other's have seen, but also what they have missed, and thus learning to see in new ways.

The Wittes and Kerwin have defined four basic types of ignorance.... The major ones are: 1) the things we know we do not know (overt ignorance), which are the things that normal disciplinary research tends to address; 2) the things we don't know we don't know (hidden ignorance), which are things we discover through error, serendipity, or trans-disciplinary comparisons; 3) the things we think we know but we don't (ignorance masquerading as knowledge), which usually survive because of untested assumptions or inadequate skepticism; and 4) the things we think we do not know but really do (knowledge masquerading as ignorance), which often takes the form of nontraditional sources of information ignored by existing disciplinary paradigms.

Root-Bernstein, 2000, p. 12

Effective scientists bring empathy, emotion, imagination, and a sense of play into their research projects and their classrooms. They frequently use metaphor, visualization, and real-life examples to ensure richer understanding of the problem or subject matter at hand. As disciplinary metaphors and forms of envisaging vary, so too do perspective and insight.

In fact, when the world's most creative thinkers are questioned, we find a basic set of tools that in various combinations are at the root of their creative understanding and that guide their creative endeavours. These tools are not the sparks that arise mysteriously from the mind of genius; on the contrary, they are tools that are known and may be learned and honed. They include: *observing, imaging, abstracting, recognizing patterns, forming patterns, analogizing, body thinking, empathizing, dimensional thinking, modelling, playing, transforming, and synthesizing* (Root-Bernstein & Root-Bernstein, 1999; see pp. 25–27 for definitions). Each of these tools can be introduced and developed through multidisciplinary collaborations and integrated learning opportunities.

2.2 Problem Definition and Motivation

At the heart of creative individuals and collaborations is the ability to define problems, an often childlike curiosity that instills excitement about that which is unknown, and the need to pursue solutions. Individuals and teams must find, discover, or define a problem or problems and develop measurable goals. For example, it is often more fruitful to define the sub-problems than it is to focus on solutions.

2.3 Team Tension

A balance must be sought between a tolerance of diversity and the generative interplay of tension

that often leads to conditions in which creativity may flourish. Diversified teams create tension and conflict that can act as catalysts to creative solutions. There is value in nurturing healthy opposition within multi-disciplinary collaborations.

2.4 Multi-disciplinarity and Adhocracy

Typically, individuals require a certain expertise and a certain flexibility for creativity to flourish. This is mirrored within teams where often the most successful are multi-disciplinary and are comprised of experienced and novice members alike; what is lost to rigidity is gained by effective knowledge and mastery of discipline, and what is lost through inexperience is gained in flexibility. The most effective collaborations are non-hierarchical. Granted, non-hierarchical collaborations may be difficult to achieve when combining experienced and novice members, but it is paramount to the process that intellectual equality be respected. Teams should be characterized by an informality and a freedom to say what is on one's mind. Needed are collaborations that foster the interaction of individuals who bring a wide variety of skills and backgrounds to a problem.

> *Tomorrow ... many solutions will arise when some creative person links existing knowledge in new ways. This will require our separate disciplines to mix more. What may this involve? Certainly, artist must speak with scientist, scientist with laborer and poet, and business people with all. But maybe it's time for scientists to give full value and respect to a new perspective — from the reductionism of the scientific method to the integrative perspective of the social sciences and the humanities.*
>
> **Dr. Peter Hackett**
> **Edmonton Symposium**

The fluidity of organizations must be such that it allows for the rapid formation and dissolution of teams excited by a particular problem. Finally, underlined should be the crucial fact that it is the problem and not the individual that is of central importance.

Examined to this point have been the various implications of viewing creativity and innovation as a process and valuing multi-disciplinarity, both individually and collaboratively. It should be noted that these findings apply equally to individuals, schools, governments, and Granting Councils. In section 3.0, additional general and specific recommendations for fostering environments conducive to the creative process will be presented.

3.0 Recommendations for Governments, Schools, and Granting Councils

3.1 Encourage Multi-disciplinarity

Great benefits and rewards await the nation whose schools and Granting Councils encourage multi-disciplinary study and collaboration, and, hence, creativity and innovation.

Fostering multi-disciplinarity may be accomplished in several ways. Schools should continue to encourage an integrated curriculum with assignments and classroom activities that are problem- rather than discipline-based. Teachers should encourage empathy and explain using real-life examples and analogies from a variety of perspectives and disciplines. In fact, Canadian schools should seek to encourage each of the thinking tools reviewed in section 2.1. These are the creative skills that are needed in artistic, business, university, and research settings.

Encouraging these skills should be continued by universities not only by permitting but also by promoting cross-disciplinary study — for example, by allowing students to combine seemingly unrelated fields such as music and engineering or computer science, history and education; imagination is the only limit to novel and potentially productive combinations. A certain percentage of university appointments should be reserved for multi-disciplinary positions. As well, alternative career promotion protocols should be investigated, since the hierarchical "principle investigator" model can be inappropriate for assessing these types of creative collaborations.

The Federal Government should make additional funds available to each of the Granting Councils (the Canada Council for the Arts, the Canadian Institutes of Health Research, the Natural Science and Engineering Research Council, and the Social Sciences & Humanities Research Council) that are specifically earmarked for truly cross-disciplinary initiatives of the sort likely to encourage creativity and innovation. Such funds would cultivate the networking of researchers from divergent disciplinary backgrounds, not just teams from closely allied disciplines. These funds should be allocated for joint Council sponsorship of projects that span funding bodies. Joint sponsorship would help alleviate the catch-22 scenario that arises when multi-disciplinary projects are not funded because they do not clearly fall under the purview of one funding body or another. For example, a recent research project that sought to examine drama as a way of knowing did not receive funding from the Granting Councils because it was deemed too artistic for SSHRC and too scientific for the Canada Council for the Arts. Such projects are bound to become more frequent as researchers increasingly participate in various multi-disciplinary collaborations and must be addressed.

3.2 Risk, Play, and Great Expectations

Play is the learning by making risky attempts in a set of circumstances where failure is likely, but the consequences are nil.

Dr. Tom Brzustowski
Edmonton Symposium

Creative pursuits require persistence, aiming high, keeping a sense of humour and a sense of play — a childlike curiosity and wonderment is paramount for seasoned scientists and young children alike. Equally important is the need for emotionally and intellectually safe environments in which failure is seen as a successful learning opportunity. Scientists and school children should be encouraged to ask questions and to seek their answers in unlikely directions.

The creative world is the vast abyss beyond what is known. It is the land of total possibility, a blank sheet of paper that is the land of the eagle, where our true power as human beings "dwells," is found, and is expressed.... Einstein, developing his theory of relativity, made this leap of recreating a whole new way of looking at the universe, although the world around him lived in a universe created by Newton. All of these creative people that have created the vast knowledge we have today took the personal responsibility of expressing this marvelous gift that each one of us has. The reason most of us do not exercise or use this powerful gift is that we operate from fear. We are terrified of looking bad, of failing, of being ostracized from the group. Fear is unlimited. It is our fear that keeps us small.

Mr. Douglas J. Cardinal
Edmonton Symposium

Governments, schools, and Granting Councils must recognize the importance of a creatively risk-free environment and the vital role that play plays in fostering arenas and contexts in which learning, creativity, and innovation may flourish.

With this in mind, Granting Councils should allow for numerous small research grants to be allocated to projects that are seen as high-risk, highly likely to fail, but nonetheless low-risk in terms of monetary investment and potentially high-gain in terms of creativity and innovation. Funding should be made available for speculative, seed research that is perhaps not perceived as strategic or valuable within current paradigms. Granting Councils should fund and be more tolerant of high-risk research ventures.

Our schools are taking far too many bright young children, avid learners and naturally creative, and making them dull-eyed, alienated, bullied or bullying, and bored... So, much of the time, does another of our cherished institutions: peer review. And for much the same reason. Chopping off the right-hand part of creativity's bell curve — those rarefied regions of excellence — is seen as the price to pay for the left-hand, underachieving part.

Dr. Peter Hackett
Closing remarks, Edmonton Symposium

3.3 Time to Explore and a Tolerance of Ambiguity

Because creative breakthroughs are often long in the making and require much tolerance for ambiguity, creative research is a long-term investment. Basic research is the well-spring of many innovative products and market applications; however, set directions are frequently unclear, and often require years of exploration before discoveries are made. Creative researchers must be prepared to tolerate, even relish, the long-term and ambiguous nature of their enterprise. Granting Councils must also be willing to tolerate basic research that flows in unspecified directions, is flexible in nature, and that follows ad hoc leads into unexpected areas.

3.4 Individual and Organizational Re-invention

Creative and innovative people are often interested in many and varied areas, frequently working on several differing projects simultaneously and/or changing fields regularly. They are continually challenging and pushing themselves in order to seek answers.

Canadians and Canadian organizations must be prepared to re-examine and re-invent themselves in order to push the boundaries of creativity and innovation. The National Research Council is a good example of an organization that has managed to remain fluid enough to allow for the rapid formation and dissolution of teams that find themselves excited by particular problems.

Universities should also be flexible, perhaps allowing a certain percentage (5%) of any curriculum program to be comprised of ad hoc courses that bypass the standard assessment procedures typically involved when attempting to introduce new courses. Programs should be reevaluated and possibly redesigned every five years; universities should be more willing to embrace new courses and new models. For instance, varying the standard thirteen-week term to create alternative delivery methods and lengths would be a welcomed possibility. Taking a page from the high-technology firms that have recognized the vital importance of seeking and rewarding creative individuals, universities, and Granting Councils should also reward creativity and innovation. Creativity and innovation should be made an overt goal to strive for. "How can we be more innovative?" and "How can we encourage more creativity?" should be questions often asked by administrators, researchers, and educators.

3.5 Creating a Culture of Creativity and Innovation

Recent research into the effects of diversity and multi-culturalism on creativity suggests that

multi-cultural policies are headed in the right direction.

> *The diversification of knowledge in its domains surely adds to information. On the other hand, cultural and populational diversity in schools bring additional information.... The more the public system of knowledge is rich and diversified, the more it provides the child with generalisations to confront with her or his particularities.... Education, if conceived as a critical and dialectical process (Popper, 1994) between the individuality of the child and a cumulative and diversified knowledge, is the best means to foster creativity in a society.*
>
> **Dr. Sonia Mansour-Robaey**
> Edmonton Symposium, 2000

As young children encounter diverse environments, the structure and combination of neuronal groups within their young minds are actually physically altered — rendered more likely to produce novel thought patterns and combinations.

These insights and findings coupled with the previously reviewed creative effects of group diversification (see 2.3) make a compelling case for arguing that a creative and innovative culture is a diverse culture.

However, the suggestions to this point are not sufficient. If the Federal Government wants to create a culture of creativity and innovation, then it must also encourage and make additional funds available for exchanges between researchers from diverse cultures. As well, Granting Councils should be rewarding researchers who have been successfully creative and innovative in the past, even if they are now looking to challenge their creative minds by attempting to work in new fields.

Governments should sponsor further colloquia, debates, and public lectures on the topic of creativity and innovation in the arts and sciences. University administrations, business and industry leaders, educators, and the general public need to be made urgently aware of the increasingly crucial importance that creativity and innovation play in the knowledge-based economies of the 21st century. A greater awareness and respect for the cross-pollinary effects and seminal importance of Science–Art interactions must also be generated, for, as observed earlier, science and technology have never flourished in the absence of a similar flourishing of the arts.

4.0 Conclusion

If the Federal Government truly wishes to foster a creative and innovative society in Canada then it must continue to move in the directions outlined in this Report.

> *[In order to create] a society in which people with creativity, vision, and determination — our*

> *researchers, educators, inventors, and artists — are encouraged to succeed. To succeed here, not somewhere else. To succeed ... in a country and society where new ideas are welcomed and supported.*
>
> Speech by the Honourable John Manley
> Dec. 1, 1999, to Innovation Canada:
> Alliances for the New Millennium

Professor Bentley's call for the formulation of a Task Force on Creativity, Inventiveness, Innovation, and Culture, falling under the combined aegis of the Granting Councils (Canada Council, CIHR, NSERC, and SSHRC), the Humanities and Social Sciences Federation of Canada (HSSFC), the National Research Council (NRC), as well as other interested agencies and organizations, should be acted upon in the near future.

It is especially important that this be done soon because, in the area of creativity and innovation, Canadian society already lags behind Britain, which established a National Advisory Committee on Creative and Cultural Education in 1998, and Europe, where the Creative Europe project has been in existence since 1999 and other projects on the topic of creativity and culture since 1993.

In conclusion, this Report recommends that for Canada to most effectively reap the rewards generated from fostering and promoting a culture of creativity and innovation, an advisory committee should be established to seek additional input from, and provide advice to, a wide variety of stakeholders in the arts, education, sciences, social sciences, medicine, business, and industry from across Canada. The initial task of the Committee should be to explore precisely how the recommendations of this Report may be most effectively implemented and integrated into current organizational, educational, and funding models. Above all, the Federal Government must recognize the importance of creativity and innovation to Canada's future well-being and use all the ways and means at its disposal to ensure a bright future for all Canadians by fostering their powers of creation and innovation.

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Appendix II. Creativity Conferences, Comments, and Quotes

The Government of Canada's Commitment to Creativity and Innovation

One of the major supporters of the public communications activities associated with the Millennium Conferences series is Industry Canada, a department of the federal government. The department has an important role in the development of policies and programs that affect many national agencies and services in both science, technology, social sciences, and humanities.

> *"Innovation and Creativity are at the forefront of the government's agenda and of the vision of Industry Canada.*
>
> *The foundation of Canada's future prosperity will be new ideas, coupled with the inspiration, creativity, and courage to see them through to the benefit of Canadians."*
>
> **V. Peter Harder**
> *Deputy Minister*
> *Industry Canada*
> *July 2000*

The Future Internet and Collaborative Learning over "Fat Pipes"

Canadian researchers hope to make special contribution to the development of tomorrow's Internet under the long-term collaboration agreement signed between the National Research Council of Canada (NRC) and the National Arts Centre of Canada (NAC) on June 20, 2000, the eve of the Creativity 2000 conference.

An improved Internet based on new "broadband" technology is now being developed by organizations around the world, including the NRC, the Communications Research Centre Canada (CRC), and CANARIE (Canada's Advanced Internet Development Organization). Basically, broadband means that the physical network connections will be carrying more information, and transporting it faster than the Internet of the 20th century. These "fat pipes" will consist of optical fibre cables or, alternatively, radio transmission between fixed antenna and satellites.

> *"A few years ago, it was impossible to imagine today's Internet. Similarly, we do not know what tomorrow's broadband Internet will be like. But we do know that we want it to help people learn together by being able to see and talk to each other, across Canada and the world. In research language, we are exploring tools for 'video-mediated communication' to facilitate 'collaborative learning.' In plain language, this means is that we are using broadband Internet's fat pipes to connect together groups of people at several sites by live video, allowing them to share and experience each others' knowledge and ideas.*
>
> **Dr. Martin Brooks**
> *Group Leader, Interactive Information*
> *Institute for Information Technology*
> *June 2000*

By working with NAC Orchestra Music Director, Pinchas Zukerman, and others with extensive experience with live video teaching, NRC scientists and their colleagues at CRC and CANARIE hope to use broadband learning technologies to build passion for the arts and new tools for education. At Creativity 2000, Maestro Zukerman demonstrated the power of new telecommunications technologies by staging a violin lesson over a satellite link with a student in a remote location whose image was projected on a big screen in the NAC Theatre. Maestro Zukerman not only spoke about the power that technology can play in bringing people together, but also the similarity between artistic endeavours and scientific research.

> *"Music has many, many elements, like the sciences. Everybody divides everything all the time, but it's totally untrue. We are mathematics as they are in science, and they should be the way we are in science."*
>
> **Pinchas Zukerman**
> *Music Director*
> *National Arts Centre of Canada Orchestra*
> *Creativity 2000*

Canada's Role in *The Ascent of Man*

Jacob Bronowski was a mathematician and a man of letters who not only achieved high honours in scientific endeavours but also received critical acclaim for his poetry and prose.

A military reseacher, Bronowski changed careers after seeing the ruins of Nagasaki during a post-war scientific mission to Japan. He pursued the life sciences, the study of human nature, and the evolution of culture. *The Ascent of Man*, the BBC television series that linked science, art, and philosophy in the story of human history, was his last major project. Canada has an enduring association with both the art and technology of this epic TV series through its computer animation sequences produced by the then world-leading centre for such work at the National Research Council (NRC) in Ottawa. Coincidentally, Canada's pioneering work in computer animation was often held up in the Millennium Conferences as an example of the creative power of a merger of arts and sciences.

> *"In every age there is a turning point — a new way of seeing and asserting the coherence of the world."*
>
> **Jacob Bronowski**
> *The Ascent of Man, 1973*

Merge Arts and High Tech with a Career in Industrial Design

One occupation that provides artistic and visually creative young people with an opportunity to participate in the high-technology, advanced manufacturing, and engineering worlds is industrial design.

The study of industrial design typically involves art, science, engineering, business, ergonomics, social issues, environmental studies, and psychology. The School of Industrial Design at Carleton University, a supporter of the Millennium Conferences on Creativity in the Arts and Sciences and one of the leading schools in North America offering undergraduate programs in Industrial Design, has, since 1995, given secondary school students across Canada an opportunity to experience the field through its annual High School Industrial Design Competition.

"I much admire the Creativity initiative. Long may it continue."

Professor Brian Burns
Director, School of Industrial Design
Carleton University
September 2000

The Professor of Literature Who Changed High Tech

American Geoffrey Moore holds a bachelor's degree from Stanford University and a Ph.D. from the University of Washington, both in literature, and worked as an English professor for many years before turning his mind to the high-technology industry. His books have not only been successful as best sellers, they have articulated visual metaphors that facilitated the development of the high-technology industry through their wide acceptance as apt descriptions of the challenges facing the industry and strategies for confronting them. Today, he is a consultant, leading authority on high-tech growth, and venture capitalist, who came to Ottawa in September 2000 to announce that his firm was investing $6.8 million in Trillium Photonics, a firm created by National Research Council (NRC) researchers.

During his visit to Canada, he spoke as part of the third Asia–Pacific Economic Co-operation (APEC) R&D Leaders Forum, organized, in part, by the Ottawa Regional Innovation Office. Commenting on the imminent election of a one-tier regional government in the Ottawa region, Moore urged a co-ordinated, balanced approach to high-tech economic development reflecting upon his blended background in technology and arts.

"they should immediately go to San Jose to see how not to do it."

Author Geoffrey Moore
Ottawa
September 2000

The Artistic Side of Einstein's Brain

In 1999, Canadian scientists announced findings that may help explain Albert Einstein's creative genius. His brain, which had been removed and preserved after his death in 1955, was compared

by Dr. Sandra F. Witelson and her colleagues at McMaster University in Hamilton in the shape and size to the brains of dozens of men and women of average intelligence. In general, Einstein's brain was the same as all others except in one particular area — the region said to be responsible for both mathematical thought and the ability to think in terms of space and movement was more developed. Einstein was known for describing his scientific thinking in terms of images of a visual kind.

"We never solve our problems if we stay at the same level we were when we created them."

Albert Einstein

C.P. Snow Wasn't a "Bad Guy"

Many participants in the Millennium Conferences on Creativity in the Arts and Sciences made reference to the works of Charles Percy Snow, the British novelist and scientist whose works included "The Two Cultures and the Scientific Revolution" given as a Rede Lecture at Cambridge in 1959 and published as a small book. In it, Snow (1905–1980) highlighted the chasm between literature and science from the perspective of someone who knew both worlds.

"As an event to promote the coming together of the arts and sciences, Creativity 2000 was excellent. I'd give it an A+ — both for the intention and execution. The choice of speakers (both for their usually justifiably high profiles, prestige, and their skill as speakers) was first rate. But I would highly recommend to those who enjoyed the event or have an interest in this issue that they read C.P. Snow's essay. Contrary to the impression left by some, Snow wasn't the bad guy; he would have been the first to propose and promote an event like Creativity 2000."

Ken Stange
Author and Lecturer on
Creativity and the Psychology of Art
Nipissing University College, North Bay, Ontario

Arthur C. Clarke and Creativity 2000

"Creativity is a form of Play."

Arthur C. Clarke
June 21, 2000

Creativity 2000, the centrepiece conference on creativity in the arts and sciences staged at the National Arts Centre (NAC) on June 21st, was memorable for many reasons, including something that *did not happen*.

Author and futurist Sir Arthur C. Clarke did not have a chance to share his thoughts on the creative process as he had hoped.

Clarke, whose live participation via satellite was arranged by the Canadian offices of the British Council, was cut short in his interview with

Canadian actor and film maker Don McKeller when satellite time ran out.

Before the link to Sri Lanka, where Clarke has lived for four decades, ended, the audience and webcast viewers of Creativity 2000 were able to see Clarke on the big screen in the NAC Theatre, laughing and joking with his interviewer about his Wizard of Oz-style presence and the image of "Big Brother being watched." He told the audience, in fact, that

> *"Arthur C. Clarke is quite busy, and this is one of his clones."*

His many fans in the audience were pleased to see him in good health and cheerful. Clarke, now well into his 80s, was at the time often dependent on canes or a wheelchair. In the comments he did make on the subject of the conference, Clarke echoed the view that creativity is "play" which draws upon our childlike qualities as well as intellect, knowledge, and skill.

"*Creativity is a form of Play*" Clarke said to the Canadian audience, suggesting that in the arts "*where anything goes*" it may be more apparent, but that "*science is also a form of play: play restrained by the physical universe.*" In the weeks following Creativity 2000, organizers of the conference had a number of e-mail exchanges with the writer to apologize for the interruption in the interview and to thank him for his participation. Clarke responded to all messages despite his busy schedule.

At the time, he was not only involved in writing for books and magazines, but also addressing the numerous interview requests that arrived daily via e-mail and fax to his Sri Lankan home. He told Creativity 2000 organizers, for example, that he was overwhelmed by media and science leaders seeking his opinion on the year 2000 discovery of evidence of water on Mars.

He asked for a copy of the video of Creativity 2000 and suggested that these of his famous quotes might be relevant to this Report and the creativity discussions that he missed.

> *"We have to abandon the idea that schooling is something restricted to youth. How can it be, in a world where half the things a man knows at 20 are no longer true at 40 — and half the things he knows at 40 hadn't been discovered when he was 20?"*

> *"I don't pretend we have all the answers. But the questions are certainly worth thinking about."*

> *"The only way of finding the limits of the possible is by going beyond them into the impossible."*

> *"If an elderly but distinguished scientist says that something is possible he is almost certainly right, but if he says that it is impossible he is very probably wrong."*

In his last e-mail on the subject, Sir Arthur added, however, that of all of his thoughts relevant to the Creativity 2000 discussions,

> *"...the most famous, and I think most important: Any sufficiently advanced technology is indistinguishable from magic..."*

Clarke, considered the Godfather of Science Fiction writers, has authored over 80 books, but he recommended "the latest edition of (his book) *Profiles of the Future*" as the one that would have information of most interest to the participants of Creativity 2000.

Britain Helps Link Arts and Sciences Around the World

Creativity through the links between arts, sciences, and education is well recognized in Britain. Not surprisingly, one of the early international supporters of the Millennium Conferences on Creativity in the Arts and Sciences was the British Council, an independent international agency that encourages cultural, scientific, technological, and educational cooperation between Britain and other countries.

The Council, which has been active in Canada since 1959, is co-located with the British High Commission in Ottawa and the British Consulate-General in Montréal. Its programs include a collaboration with the National Research Council to jointly support public sector collaborative research, as well as student and staff exchanges in science and engineering.

> *"We were very impressed by the discussions at Creativity 2000 and proud to be associated with it."*
>
> **Keith F. Preston**, *Ph.D.*
> *Fund and Secretariat Administrator*
> *NRC–BC Fund*
> *The British Council Canada*

An Asian Perspective on the Need to Link Arts and Sciences

The National Science Council (Taiwan) was one of the international supporters of the Millennium Conferences on Creativity in the Arts and Sciences and a sponsor of the *Creativity and the World Banquet* on June 20, 2000. The NSC has a long-standing commitment to building bridges between the arts and sciences, as its mandate not only includes support for scientific and engineering research and the administration of science-based industrial parks, but also support for research in journalism, philosophy, literature, and other fields of humanities and social sciences. This broad perspective is reflected in the following comments.

> *"Few artists really understand science. Likewise, many scientists do not know much about art either. The question is — Is there any connection between art and science? One clue I found is 'algorithm,' which exists in both art and science. While in arts algorithms are the hidden rules*

behind many works of art, they are procedures for solving problems or backbones for writing computer programs in science or engineering. One good example is a methodology adopted by many researchers to analyze the generation of images and the composition of famous paintings in order to reveal the secret in various styles of art creation.

Technologies that merge art and science, such as hypermedia and digital libraries/museums, are being used to preserve our precious artistic knowledge and cultural legacy. For example, the National Science Council (NSC) Taiwan is sponsoring a 'digital museum' project as part of the 'Greeting a New Millennium — A 21st Century Science Development Program with Concern for the Humanities as a Main Theme.' This project establishes a model website which weaves together culture, art, science, and technology and promotes the research in related technologies for Digital Library System, such as metadata, watermark and multimedia technologies.

In Taiwan, more researchers in humanities have applied technologies such as 3D and virtual reality in their research. NSC Taiwan has recently sponsored a researcher in the Department of Chinese Literature at National Taiwan University who used 3D simulations to recreate a video show of an ancient Chinese wedding ceremony for which only the written records can be found today.

Artists in the 21st Century also can no longer evade the powerful impacts from information technologies, such as digital images, 3D animations, virtual reality, and interactive designs. The development and application of various algorithms also declares this emerge of digital arts. In November 2000, an exhibition 'Art Future 2000' held in Taipei was a big festival for both artists and scientists. Famous local and international artists were invited to display their works in the exhibition, and to participate in the Digital Art Contest. International artists and experts in hi-tech also attended a symposium in Taipei to discover the new possibilities in future arts and to discuss the future integration of art and science for improving the spirit in human life. We always welcome elite artists and scientists around the world to come to Taiwan and share with us their new thoughts and precious creative experiences."

Dr. Cheng I Weng
Chair
National Science Council (Taiwan)
December 2000

A Science for Artists and Philosophers

For those interested in learning more about science and technology, the field of astronomy offers many opportunities and issues that seem to cross boundaries and appeal to artists, humanists, young children, and the general public as well as scientists from many disciplines.

> *"The health of a culture and economy in the information age depends on its ability to contribute to basic research, to compete technologically with other nations, and to educate its citizens both in science and the arts. The pursuit of astronomy and astrophysics furthers all of these goals.*

Almost one million people annually visit Canadian observatories and planetaria ... At the university level, approximately 10,000 Canadian students elect to take non-specialist courses in astronomy each year; for most of them, it will be the only formal university contact they will have with science."

The Origins of Structure in the Universe: Canadian Astronomy and Astrophysics in the 21st Century
June 2000

Educator's Three Messages of Caution to Innovation Leaders

In December 1999, the **Canada Foundation for Innovation** and its partners staged the Innovation Canada Conference in Ottawa, which attracted research and industrial leaders from across Canada for a gathering that explored ways to promote economic growth and innovation through new alliances.

In one of the sessions, NAC Director and CEO Peter Herrndorf spoke on the power of the arts in a high-tech world saying, *"Art stimulates the brain's synapses; they get us thinking about things in different ways. The artistic capacity of a nation will have a direct impact on its ability to compete in a knowledge-based economy."*

He was followed by the then-Dean of Education at Queen's University who warned the audience of industry and research leaders on three points.

"Let me begin with three messages of caution in this midst of this celebration of creation and innovation.

Peter Herrndorf talked about the importance of bringing together the scientific, technological, literary, and artistic disciplines as equal partners in innovation. I agree with his view, and in doing so, I would like to reinforce the importance avoiding distinctions of status as well — the valuing of one enterprise over another.

- *We must not value science more than art nor art more than science — no more than we would give up one half of the brain for the other. The same goes for valuing research over teaching or the private sector over the public or vice versa. What we must value instead are the differences between the arts and sciences, the humanities and the social sciences, as well as the natural alliances between them. To do any less would enforce what Social Sciences and Humanities Research Council President Marc Renaud calls a 'culture of poverty.' And poverty in any group impoverishes us all.*

- *My second concern is that we not overlook the intangible measures of success. In addition to the performance variables and deliverables and the economic performance indicators that (Royal Bank CEO) Mr. Cleghorn described so convincingly, there must be room for acknowledging the joy that is the internal sign of creativity, and the beauty that is the sign of creativity for all to see, whether that beauty manifests itself as a sculpture or in the elegance of a mathematical proof or — as some of us saw this morning — in the*

complexity of the gear on the forehead of an ant as revealed by synchrotron light. All of these things are beautiful in their own right.

- *The third caution is this. We must not interpret lack of progress and supreme frustration as signs of failure. This is risky work and it is hard work, particularly in the early days. It will be hard, for example, to make the Canadian Institutes for Health Research work. The work will be hard, not because of a lack of natural alliances between the social sciences and biomedical disciplines, or between the government, universities, and private sector, for that matter, but because there is a need to break down the silos while at the same time, honouring specializations as a new research culture is formed. As we move forward with CIHR and other initiatives like it, it will be imperative to remind ourselves that natural processes are hard work — a natural process, and if I remember correctly, birth is very hard work indeed.*

Speaking of birth, it is no coincidence that — quite independently — most of tonight's speakers have asked us to cast our minds back to Renaissance.

La Renaissance a été un époque extraordinaire en matière de réalisations et de célébration du génie et du potentiel humains. Synonymous with the Renaissance is the figure of Leonardo da Vinci. Five hundred years from now, people will still be talking about him. But perhaps not everyone knows that Leonardo was granted a position in Milan in his capacity as a musician, although the services he also offered included those of architect, painter, sculptor, and engineer. Indeed, Leonardo was permitted to do his science and engineering so long as it did not interfere with his art. One wonders if he were living now, if he would be permitted to do his art so long as it did not interfere with his science — an equally bizarre restriction, for it is each that feeds the other.

Let me now turn to a contemporary Renaissance figure, the Canadian astronaut Julie Payette, who is a scientist, engineer, linguist, scuba diver, jet pilot, triathlete, soprano singer, and pianist. In a conversation I had with Dr. Payette when she was recently recognized at Queen's with an honorary doctorate, I asked her about her many pursuits. For her, they are inseparable. She said to me — with joy and a twinkle in her eye — 'Everything I have done has led to this.'

I believe that we are ripe for a new Renaissance, a new time of unprecedented achievements, of countless Julie Payettes and Pinchus Zuckermans, of celebration of human spirit and potential, of education, of hard work, of beauty, and of joy. A time to value the arts, the social sciences, the humanities, the sciences, and to nurture the natural alliances between them.

This is creation. This is innovation."

Professor Rena Upitis
(then) Dean of Education
Queen's University
Innovation Canada
December 1999

Teach Science Fiction as Both Good Art and Good Science

As professionals, both scientists and writers of science fiction extrapolate on the current state of science and technology, albeit for different reasons.

There are historical examples of fiction writers who have made reasoned and accurate predictions of the advent of certain technologies, often well in advance of their scientific counterparts (Jules Verne and the space race, H.G. Wells and the atom bomb, Arthur C. Clarke and geosynchronous satellites). There also exist significant counterexamples, such as the Internet, which were largely unpredicted by both communities.

There is a mutual reliance between the two disciplines. Today, in an effort toward enhanced realism, which is in part motivated by the increase in scientific literacy of their audience, fiction writers often draw inspiration from the scientific literature, sometimes interfacing directly with the scientists themselves. For their own part, scientists tend to be avid (if sometimes closet) science fiction fans. There are also those people who bridge the disciplines, working by day in scientific and technical professions while also authoring fiction at night.

The Canadian Science/Science Fiction Conference in September 2000 investigated the broad relationships between science and science fiction, including the degree to which science fiction anticipates science. The Conference attracted high-profile writers such as the "Dean of Canadian Science Fiction" Robert J. Sawyer and science journalists such as CBC's Bob McDonald. One of the participants, Julie E. Czerneda, described not only how she brings her fascination with biology to her science fiction works, but also to the classroom. Her books often target young readers with original, illustrated SF stories based on elementary science curriculum. The companion resources have experiments, integration ideas, background information, and other tools to help teachers use the speculation and creativity of science fiction literature to encourage students to critically assess the scientific information in it.

"Art imitates life ... or is it the other way around?"

Dr. Michael Greenspan
Organizer
Canadian Science/Science Fiction Conference 2000

Astronaut Tells Students How to Travel Through Time

On June 14, 1999, former Canadian astronaut Major Mike McKay addressed over 200 students from local schools in an auditorium of the historic National Research Laboratories Building at

100 Sussex Drive, Ottawa. Major McKay made a presentation about the science of space and time and encouraged the students to use their imaginations to travel through space and time and to make their dreams come true. His presentation was combined with the unveiling of the Canadian Millennium Clock, a clock linked directly to the national cesium beam atomic clocks and Canada's official time. Canadian scientists built the world's first continuously operating primary atomic clock in the 1970s. The Canadian Millennium Clock celebrates this achievement.

"The best way to travel through time is to use your imagination."

Major Mike McKay
Addressing students
June 1999

How Canadian Technology Helps Renaissance Art

In October 1999, experts in 3D imaging and modeling technologies from around the world met in Ottawa for a series of events hosted by scientists at the National Research Council of Canada (NRC). NRC's Institute for Information Technology (IIT) in Ottawa is the recognized world leader in a three-dimensional imaging technology that has seen applications in fields ranging from art preservation and computer animation to engineering design and medicine. Canadian high school students have worked with the researchers to reconstruct 3D computer models of buildings and cities in projects that blend the teaching of leading edge computer skills with historical research in the 3D Historical Cities Project.

The October 1999 3D technology events were kicked off with the Canada–Italy Workshop on Heritage Applications of Digital 3D Imaging. This workshop highlighted the outstanding benefits of high-resolution three-dimensional imaging of important architectural structures, archaeological sites, sculptures, and museum collections. NRC scientists have participated in a number of many international programs including the international Digital Michelangelo Project to gather detailed measurements of Michelangelo's sculptures, including the celebrated David, and a collaboration with the University of Padua, Italy, to demonstrate a portable 3D camera in a museum setting. The use of 3D technologies in art and heritage applications were among the success stories of scientific partnerships with the artistic community highlighted in the media in connection with the Millennium Conferences.

"We decided that we would like a higher-quality gold standard for our scan. The best laser scanner in the world is at (Canada's) National Research Council."

Professor Marc Levoy
Stanford University
Head, Digital Michelangelo Project
October 1999

A Conference for Dancers at a Research Laboratory

In mid-November 1999, the National Arts Centre of Canada and the National Research Council in association with the School of Dance and the Canadian Medical Association sponsored three satellite downlink sessions of "Not Just Any Body — a Global Conference to Advance Health, Well-Being, and Excellence in Dance and Dancers." Members of the Ottawa area dance, arts, and health community attended the sessions in the auditorium of an NRC laboratory building. The main presentations in Toronto and the Hague were viewed via satellite on a large screen, and the participants then discussed the links between creativity and health and the challenges of merging artistic and technical excellence in dance.

The speakers in Toronto included creativity expert Mihaly Csikszentmihalyi, the author of *Flow: The Psychology of Optimal Experience*. He and others spoke on how individuals and organizations can achieve peak performance. Csikszentmihalyi described his theory that people experience "flow" when immersed in creative work that they love. This concept of flow refers to a state of happiness that an individual experiences when he is engaged in a well-defined task that is both challenging and within his capabilities.

"Dancers must marry art and technique to be creative."

Audience participant in "Not Just Any Body" downlink session

Buffy Sainte-Marie — an Artist Who Promotes Science

The National Aboriginal Career Symposium seeks to encourage students to stay in school, focus on career-oriented educational choices, and maintain their cultural identity within the workplace. In October 1999, the fourth such event was held in Ottawa.

Native American astronaut Lt. Commander John Herrington, NASA, and Academy Award-winning songwriter, singer, visual artist, and educator Buffy Sainte-Marie delivered keynote addresses at the opening ceremonies. Buffy Sainte-Marie also hosted a workshop in connection with the

Cradleboard Teaching Project, a program to develop unique education partnerships as well as curriculum materials such as the CD-ROM "Science: Through Native American Eyes."

A teacher before she ever started singing, Sainte-Marie has continually used her talents in art, music, and cutting edge technology to educate both on stage and in the classroom. Buffy Sainte-Marie's work exemplifies the harmony and creativity that flows between the arts and sciences. Her participation in the Symposium was sponsored by the Millennium Conferences on Creativity in the Arts and Sciences.

> *"to bring out the best of our hearts into our presence ... this Navajo Elder (said), just remember, computers, telephones, fax machines, whatever people may invent ... nothing takes the place of the fire ..."*
>
> **Buffy Sainte-Marie**
> *National Aboriginal Career Symposium*
> *Ottawa*
> *October 1999*

Creativity and the Economics of the Future

On Friday, October 15, 1999, the NRC Entrepreneurship Program in collaboration with the Millennium Conferences on Creativity in the Arts and Sciences staged a special presentation on the economics of the future and the role of creativity.

As part of this special Lunch-time Speaker Series event, Dr. Sherry Cooper, Senior Vice-President and Chief Economist of Nesbitt Burns, discussed creativity and innovation in a talk entitled "Profit and Prosper in the New Millennium."

> *"Creativity is important in the new economy as we need to create more Ottawa-style high-tech regions and to focus on creating new businesses industries rather than propping up those that are fading."*
>
> **Dr. Sherry Cooper**
> *Economist*
> *October 15, 1999*

Rock and Roll — Physics and Math

In mid-February 2000, 150 Ottawa students were given the formula for becoming a Rock Star. The key, according to Paul Hoffert, former researcher and co-founder of the band Lighthouse, is to use your imagination and to mix science and technology with rock 'n roll. Hoffert spoke to an audience of primarily music students, who were eager to learn how to break into the international entertainment business.

Hoffert encouraged these aspiring musicians to be technology savvy, and not to limit their focus to just the arts.

Hoffert spoke of the "Renaissance Man," integrating all skills together and working toward a general knowledge base. Hoffert encouraged students to learn how to capture their sound and image digitally. Hoffert's wisdom was backed up by current Lighthouse singer Dan Clancy. He also stressed the value of learning the technical side of music, which opens up new possibilities such as independent CD production and marketing on the web.

> *"In our society, arts and science have been very separated and essentially all the specialization that's happened isn't working. The digital age that we're coming to is so different from the industrial revolution that we need a different way to think about things."*
>
> **Paul Hoffert**
> *Founder of rock group Lighthouse*
> *Former Chair of Ontario Arts Council and Researcher*

"*The Einstein of Dance*"

Canadian choreographer Édouard Lock's approach to his work and his impact on the world of dance was compared to Albert Einstein's influence on physics in a newspaper profile marking the June 2000 Canada Dance Festival. The Festival, co-produced by the National Arts Centre, included a tribute to Lock, in honour of the 20th anniversary of his innovative company, La La La Human Steps. A producer of contemporary dance, Jack Udashkin, was quoted as saying that Lock, whose innovative dance troupe has entertained in large stadiums around the world,

> *"... is like (James) Joyce and Einstein in terms of their influence on the forms in which they worked, and the way in which they used older forms to develop new forms."*

Fractals and the Underpainter

Creativity 2000 sought to encourage new interactions between the arts and sciences through discussions that brought exceptional individuals in both worlds together. In a morning session entitled "Infinite Possibilities," author and poet Jane Urquhart shared the stage with a giant screen, which allowed for live interaction with mathematician and internationally recognized Father of Fractal Geometry Benôit Mandelbrot. Urquhart, whose poetry and novels (*The Whirlpool*, *Changing Heaven*, *Away*, and *The Underpainter*) have been published around the world, presented a reading and commented on

the theme of the conference from her personal experiences.

> *"Both scientists and artists are rooted in the perceived world...*
>
> *creátivity is important in the sciences and in the arts, and I think that had I been a little more exposed to that as a student, I think that I would have been a much better student, probably a much better English and History student, as well as a Maths and Sciences student."*

Jane Urquhart
Poet and Author
Creativity 2000

The Sterling Professor of Mathematical Sciences at Yale University and IBM Fellow Emeritus, Mandelbrot has received international recognition and honours for his work and influence on geometry, physics, computer science, finance, and art. Yet, he told the audience that his study of fractals, the geometry of patterns at different scales, has had an impact beyond anything he imagined.

> *"Gradually, we had more and more references to fractality, not from scientists (they came later), but from the artists, the musicians, the poets..."*
>
> *"Very great contemporary musicians came to me to tell me 'Do you realize that your work has helped us to understand music?'*
>
> *And I thought 'How can that be? I never imagined that possible!' They told me of how they thought of a piece of music as being whole with parts, and parts, and parts, the way in which we are taught about it, in a certain sense, without the proper language, was very much in this context."*
>
> *"There is no marker on the earth stating that you are leaving mathematics and entering physics, you are leaving physics and entering finance, into music; there are no markers at all; it is all one big unified cloth."*
>
> *"The people [Arts majors] have an extraordinary thirst of mathematics if it is presented to them not primarily as the plumbing of mathematics, which is essential but which is rather dry and indeed very difficult, but as a way of thinking about patterns and structure which is not specific to thinking about one pattern of pure mathematics, physics, or engineering, but which transcends into everything."*

Benôit Mandelbrot
Father of Fractal Geometry
Creativity 2000

Trying to Sum it All Up

The daunting task of summing up the day's discussions fell on the shoulders of author and philosopher Mark Kingwell (who co-hosted the Creativity 2000 conference with National Research Council Secretary General Lucie Lapointe) in a conversation with Sir John Maddox, the theoretical physicist turned author

who is widely credited for the prestige of the international scientific journal *Nature* which he oversaw as Editor for more than 20 years.

Professor Kingwell approached his task in part by noting some of the words, names, and phrases that stood out: *"I couldn't help picking up a few tidbits during the day; things like curves and straight lines, hexagons, violins and music, Venice, Mozart, Plato, Einstein, Buckminster Fuller, Glen Gould, toys and play and children, wonder, the weather, Jane's book, flunking out of school, staying in school, what's wrong with the schools, Star Wars, risk and reward, and finding patterns ... Interesting, or useful, or beautiful, or elegant — these are some of the adjectives we use about both art and science."*

"Art and science are both conversations, and they're aspects of a larger human conversation of which this conference is a small part."

Mark Kingwell
Author and Philosopher
Creativity 2000

For his part, Sir John reiterated the need for "courage" and the view that creativity is "doing something for the first time in an imaginative way," adding that it has to be "in a way that commands the respect of the community in which you work." He also echoed the importance of study of the human brain and its relationship to the more elusive "creative mind," saying, "we are a long way away from understanding how thinking is actually accomplished in the head. It will, of course, be a great day when that is understood, but that day is a long way away, in my opinion." He added his hope that the conference would have an impact.

"As a visitor, I wish that the conference is aftermathed well."

Sir John Maddox
Scientist and Author
Creativity 2000

Appendix III. Creativity 2000 Programme

NATIONAL ARTS CENTRE
OTTAWA
JUNE 21, 2000

Presented by: The National Research Council of Canada, the National Arts Centre, and the Canada Council for the Arts

CO-HOSTS

- **Mark Kingwell**, Associate Professor of Philosophy, University of Toronto
- **Lucie Lapointe**, Secretary General, National Research Council

8:00

REGISTRATION, FOYER, NATIONAL ARTS CENTRE

Performance by the School of Dance — beginning at 8:40

9:00

OPENING CEREMONIES

Her Excellency the Right Honourable Adrienne Clarkson
The Honourable Herb Gray, Deputy Prime Minister
Peter Herrndorf, Director General and CEO, National Arts Centre
Dr. Arthur J. Carty, President, National Research Council

9:20

WIRED MUSINGS

A conversation between Sir Arthur C. Clarke, author and futurist, in Sri Lanka, and Don McKellar, actor, writer, and film maker, via satellite
Sponsored by: The British Council

9:50

INFINITE POSSIBILITIES

Introduction: Dr. Peter Hackett, Vice-President of Research, National Research Council

Participants: Benoît Mandelbrot, "Father" of fractal geometry
Pinchas Zukerman, Music Director, National Arts Centre Orchestra
Jane Urquhart, author and poet

Facilitator: Jean Gagnon, Director of Programs, Daniel Langlois Foundation for the Arts, Science and Technology

Dance Solo: Benoît Lachambre (choreography by Meg Stuart)

Sponsored by: Canada Foundation for Innovation

LUNCH

Performances by the School of Dance and actor Peter Froehlich, and works on loan from the Canada Council Art Bank will be presented throughout the lunch period.

13:00

THE CREATIVE MIND

Introduction: Dr. Shirley L. Thomson, Director, Canada Council for the Arts

Participants: Dr. Albert Aguayo, Director of the Centre for Research in Neuroscience, McGill University
Dr. Margaret Boden, Professor of Philosophy and Psychology, University of Sussex
Catherine Richards, artist

Facilitator: Dr. Mark Kingwell, Associate Professor of Philosophy, University of Toronto

Dance Solo: Tedd Robinson, choreographer and performer

Sponsored by: Canadian Institutes of Health Research

15:20

RECONFIGURATIONS: STRUCTURE AND SPACE

Introduction: Peter Herrndorf, Director General and CEO, National Arts Centre

Participants: Sir Harry Kroto, Nobel laureate
Douglas Cardinal, architect

Facilitator: Don McKellar, actor, writer, film maker

Dance Solo: AnneBruce Falconer (choreography by Louise Bédard)

Sponsored by: Natural Sciences and Engineering Research Council

FUTURE INSIGHTS: "What does it all Mean?"

Participants: Dr. Mark Kingwell, Associate Professor of Philosophy, University of Toronto
Sir John Maddox, Physicist

17:50

Concluding address: Dr. Arthur J. Carty, President, National Research Council

18:00

Reception

Organizing Committee — Creativity 2000

Co-Chairs

Dr. Michel Brochu
Director, Executive Offices Secretariat
National Research Council

Mr. Bernard Geneste
Senior Director, Corporate Services and
Corporate Secretary
National Arts Centre

Members

Ms. Kelly Ann Beaton
Director, Communications
National Arts Centre

Dr. John Bradley
Institute for Research in Construction
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Mr. Martin Brooks
Head, Interactive Information Group
Institute for Information Technology
National Research Council

Mr. Richard I. (Dick) Doyle
Project Manager
Millenium Conferences on
Creativity in the Arts and Science
National Research Council

Mr. Keith Kelly
Director, Planning and Research
Canada Council for the Arts

Mr. Robert Laliberté
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National Research Council

Dr. Dennis Salahub
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Steacie Institute for Molecular Sciences
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Ms. Katherine Watson
Producer
Creativity 2000

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Ms. Sylvie Brunette
Business Relations Office
National Research Council

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